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Accident proneness, does it exist? A review and meta-analysis

Ellen Visser [a,*], Ysbrand J. Pijl [a], Ronald P. Stolk [b], Jan Neeleman [a], Judith G.M. Rosmalen [a]

[a] *Department of Psychiatry, University Medical Center Groningen, Department of Psychiatry, PO Box 30.001, 9700 RB Groningen, The Netherlands*
[b] *Clinical Epidemiology, University Medical Center Groningen, University of Groningen, PO Box 30.001, 9700 RB Groningen, The Netherlands*

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Abstract

Accident related health problems have been suggested to cluster within persons. This phenomenon became known as accident proneness and has been a subject of many discussions. This study provides an overview of accident proneness. Therefore, 79 articles with empirical data on accident rates were identified from databases Embase, Medline, and Psychinfo. First, definitions of accidents varied highly, but most studies focused on accidents resulting in injuries requiring medical attention. Second, operationalisations of accident proneness varied highly. Studies categorised individuals into groups with ascending accident rates or made non-accident, accident, and repetitive accident groups. Third, studies examined accidents in specific contexts (traffic, work, and sports) or populations (children, students, and patients). Therefore, we concluded that no overall prevalence rate of accident proneness could be given due to the large variety in operationalisations. However, a meta-analysis of the distribution of accidents in the general population showed that the observed number of individuals with repeated accidents was higher than the number expected by chance. In conclusion, accident proneness exists, but its study is severely hampered by the variation in operationalisations of the concept. In an effort to reach professional consensus on the concept, we end this paper with recommendations for further research.

Keywords: Accident proneness; Accident; Review; Meta-analysis

1. Introduction

The concept of accident proneness is used to indicate that some individuals have more accident-related health problems than others. Greenwood and Woods (1919) were the first to observe that a relatively small proportion of workers in a British munitions factory had most of the accidents. They suggested that the explanation for this clustering of accidents in certain persons was to be found in their personality make up. Harking back to Freud's notion of the death instinct (Freud, 1922), Farmer and Chambers (1929) introduced the term *accident proneness* for this phenomenon (Haight, 2001). More recent evidence is now emerging that accident proneness is indeed a personality feature. A meta-analysis of causes of death among the psychosocially vulnerable suggested that mental disorder (often a lifelong affliction), addiction and low socio-economic status put people at risk of dying prematurely of accidents (Neeleman, 2001), whilst another study indicated that impulsivity during adolescence is predictive of premature accidental death (Neeleman et al., 1998). Further evidence to suggest that accident proneness is a personality feature originates from research among children and youngsters. These studies do indicate the existence of something akin to injury liability. For instance, there are children living in unsafe environments who never experience an accident while others living in optimal conditions suffer repeatedly from accidents (Manheimer and Mellinger, 1967). Also, gender plays an important role as a predictor for accident proneness: boys are more likely to be involved in accidents than girls. Accident-prone children may be accident-prone lifelong, but it has also been suggested that accident proneness may also be an episodic disability, for instance, due to side effects of sedative medication (Hindmarch, 1991). Engel (1991) suggests that lifelong accident prone individuals are also more likely to suffer from organic illnesses. Thus, he went as far as attributing both liability to accidents and susceptibility to diseases to personal attributes.

However, the concept of accident proneness (or its equivalents: injury proneness, liability to accidents and injuries) remains subject of much controversy, debate and conceptual confusion (McKenna, 1983). An often-mentioned problem is that attributing accident proneness to certain individuals would lay blame them in stead of on shortcomings in the health and safety regulations in the workplace (Green, 1991). In this

* Corresponding author. Tel.: +31 50 3612032/2079; fax: +31 50 3619722.
E-mail address: e.visser@med.umcg.nl (E. Visser).

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respect, it has acted as a barrier in the development of preventive occupational health and safety principles and practices (Sass and Crook, 1981). Still, the concept of a personal liability to accidents has remained an active component of medical knowledge, although a large variety of definitions of accident proneness was used in the past. It was striking that, since a discussion about the concept in 1991 in the Journal of the Royal Society of Medicine (Engel, 1991; Green, 1991; Hindmarch, 1991), the term accident proneness was found in the title of only one article with empirical data (Baker et al., 1995). Instead, words like repetitive injuries, recurrent injuries, or injury liability were used. In this respect, a clear distinction can be made between accident liability, which refers to both personal and environmental factors determining accident rate, and accident proneness, which refers to personal factors only (Bernacki, 1976).

As a starting point of this review, we regard accident proneness as the tendency of an individual to experience more accidents than otherwise identical individuals (in terms of basic personal characteristics like age, gender and place of residence), due to stable personality characteristics. We did not include exposure to risk as part of the definition itself, because the extent to which individuals expose themselves to risk may be largely determined by personality characteristics. In studies of selected subpopulations or towards specific types of accidents, exposure can sometimes be considered to be largely person independent (e.g., in traffic contexts where exposure has been quantified by number of driving days (Shaw and Sichel, 1971)). In these types of studies, the amount of exposure should be taken into account in the operationalisation of accident rate.

Prevalence rates and determinants of accident proneness have been studied previously. However, in these studies, populations, methods and operationalisations of accident proneness varied greatly, limiting their comparability and generalizability. Therefore, the first aim of this study was to provide an overview of operationalisations of accident proneness in an attempt to come to professional consensus of the concept. In addition, despite the longstanding discussion on the concept of accident proneness, there is still no formal proof of its existence. Therefore, the second aim of this paper was to quantify accident proneness by means of a meta-analysis.

2. Methods

2.1. Literature search

Articles were retrieved from the databases Embase (1988–2005), Medline (1966–2005) and Psychinfo (1966–2005) using the following search terms: accident prone(ness), injury prone(ness), repetitive accident(s), repetitive injur(y)(ies), recurrent accident(s), recurrent injur(y)(ies), multiple accident(s), accident liability or injury liability. These terms had to appear either in the title or the abstract. We selected articles that were based on empirical studies in humans. These studies were peer reviewed and written in English. This resulted in 481 articles. Studies were excluded when they focused on specific somatic diseases or physical impairments (115) or intentional self-harm (20). Also reviews (20), letters and comments (65), studies not reporting on accidents (58), and studies on very specific injuries in specific contexts (142) were excluded. Of the remaining 61 papers, references published in the same time frame as mentioned above were also screened for operationalisations of accident proneness or prevalence rates of accident proneness or repetitive accidents (18). All available 79 papers were screened for operationalisations and prevalence rates related to accident proneness.

2.2. Statistical analysis

To determine whether there exists systematic variation in the distribution of accidents over individuals, we performed a meta-analysis. We identified 15 studies with quantitative data on the distribution of accidents in the general population and calculated the distribution of accidents among individuals that would be expected by chance based on the Poisson distribution. Next, we collected prevalence rates of individuals with none, one and more than one accident within these studies and compared these rates with the expected rates. Three studies did not provide these data and therefore, these studies were excluded for analysis (Bradbury et al., 1999; Gallagher et al., 1984; Nicholl et al., 1995).

As an indication for the strength of accident clustering in the population, we calculated odds ratios and 95% confidence intervals based on the observed and expected number of repeaters (ratio of the odds of repetition observed and the odds of repetition expected) in the general population. For this analysis, we excluded three studies (Bijttebier et al., 2003; Schwebel and Plumert, 1999; Spady et al., 2004), because the mean number of accidents per individual in the entire study period was above 1 and thus more than one accident was the normal state instead of the accident-prone state. Also, two of these studies did not provide prevalence rates of subjects with two accidents or with more than two accidents, as a result of which we could not identify an accident-prone group anyway. One study was excluded because the cohort was described twice (at age 0–5 years and age 5–10 years) and, since the effects of personality features on accident rates are more likely to be reflected in the oldest children, we decided to choose the oldest age group (Bijur et al., 1988). Odds ratios of the remaining eight studies were pooled by the fixed method to obtain a summary estimate of odds ratios and, depending on the outcome of the test for heterogeneity, we also used the random effects method and compared results of both statistical methods. A funnel plot of the effect measure against the inverse of its standard error was constructed to examine possible publication bias. Asymmetry of this funnel plot was tested using linear regression.

3. Operationalisations of accident proneness

We first made an inventory of the operationalisation of accidents proneness previously used. All 79 papers are presented in Table 1. We found that operationalisations varied highly, with respect to the definition of accidents, the operationalisation of accident proneness, the context in which the accidents occurred, and the population studied.

Table 1
Summary of included studies on population characteristics

Art no.	References	Location	Population	Sample	Operationalisation of accidents
1	Lindqvist (1989)	Sweden	General population	41,432 residents	Injuries (medical treatment)
2	Nicholl et al. (1995)	UK	General population	17,564 residents	Injuries
3	Jansson et al. (2004)	Sweden	General population	4036 residents	Injuries (hospital care)
4	Langley et al. (1983)	New Zealand	General population: children	954 children (0–7 years)	Injuries (medical treatment)
5	Gallagher et al. (1984)	USA	General population: children	87,022 children (0–19 years)	Injuries (hospital care)
6	Bijur et al. (1986)[a]	UK	General population: children	11,966 children (0–5 years)	Injuries (medical treatment)
7	Bijur et al. (1988)[a]	UK	General population: children	10,394 children (5–10 years)	Injuries (medical treatment)
8	Boyce and Sobolewski (1989)	USA	General population: children	54,874 children (6–18 years)	Injuries
9	Kogan et al. (1995)	USA	General population: children	8094 children (0–3 years)	Injuries (medical treatment)
10	Scheidt et al. (1995)	USA	General population: children	17,110 children (1–17 years)	Injuries (medical treatment)
11	Bradbury et al. (1999)	USA	General population: children	295 children (5–11 years)	Injuries (medical treatment)
12	Schwebel and Plumert (1999)	USA	General population: children	59 children (0–6 years)	Injuries (medical treatment)
13	O'Connor et al. (2000)	UK	General population: children	10,238 children (15–24 months)	Injuries
14	Bijttebier et al. (2003)	Belgium	General population: children	209 children (2–9 years)	Injuries
15	Spady et al. (2004)	Canada	General population: children	94,354 children (0–9 years)	Injuries (medical treatment)
16	Mellinger and Manheimer (1967)[b]	USA	Subpopulation: children	453 boys (0–15 years)	Injuries (medical treatment)
17	Manheimer and Mellinger (1967)[b]	USA	Subpopulation: children	684 children (0–15 years)	Injuries (medical treatment)
18	Husband and Hinton (1972)	UK	Subpopulation: children	24 children (2–14 years) with >2 injuries	Injuries (hospital care)
19	Padilla et al. (1976)	USA	Subpopulation: children	103 junior high schoolboys (13 years)	Accidents
20	Garrick and Requa (1978)	USA	Subpopulation: children	3049 high school students (12–18 years) (sports injuries)	Injuries
21	Matheny (1980)[c]	USA	Subpopulation: children	160 children (6–9 years)	Injuries
22	Eminson et al. (1986)	UK	Subpopulation: children	2013 children (0–5 years)	Injuries (medical treatment)
23	Gayton et al. (1986)	USA	Subpopulation: children	70 hyperactive children and 119 disturbed, non-hyperactive children (age unknown)	No definition of accidents
24	Matheny (1986)[c]	USA	Subpopulation: children	84 children (1–3 years) without injuries and 84 with >1 injury	Injuries
25	Matheny (1987)[c]	USA	Subpopulation: children	96 children (1–3 years) and 76 children (6–9 years)	Injuries
26	Nyman (1987)	Finland	Subpopulation: children	35 children with an injury and 235 children with an illness (0–5 years)	Injuries (hospital care)
27	McLain and Reynolds (1989)	USA	Subpopulation: children	1283 high school students (12–18 years) (sports injuries)	Injuries
28	Graham et al. (1993)	USA	Subpopulation: children	267 children with trauma and 496 children without trauma (11 years)	Injuries (hospital care)
29	Anderson et al. (1994)	USA	Subpopulation: children	1245 students (12–16 years)	Injuries (medical treatment)
30	Phillips and Matheny (1995)[c]	USA	Subpopulation: children	628 twins (0–3 years)	Injuries (medical treatment)
31	Plumert (1995)	USA	Subpopulation: children	44 children (6 years) and 44 children (8 years) and 20 college students	Injuries (medical treatment)
32	Potts et al. (1995)	USA	Subpopulation: children	83 children (6–9 years)	Injuries
33	Brook and Heim (1997)	Israel	Subpopulation: children	279 high school pupils (14–18 years)	Injuries (medical treatment)
34	Schwebel et al. (2002)	USA	Subpopulation: children	79 boys with behaviour disorders and 76 normal boys (5 years)	Injuries (medical treatment)
35	Vollrath et al. (2003)	Switzerland	Subpopulation: children	118 injured children and 184 non-injured children (10 years)	Injuries (hospital care)
36	Swensen et al. (2004)	USA	Subpopulation: children	1308 children with ADHD accident(s) and 1308 controls (16 years)	Injuries (medical treatment)
37	Qin (2005)	China	Subpopulation: children	81 children with injuries and 81 children without injuries (2 years)	Injuries (hospital care)
38	Williams and Nickels (1969)	Canada	Subpopulation: students	235 students	No definition of accidents

Table 1 (*Continued*)

Art no.	References	Location	Population	Sample	Operationalisation of accidents
39	Plummer and Das (1973)	Australia	Subpopulation: students	30 psychology students without and 30 with >1 accident	Accidents
40	Lysens et al. (1989)	Belgium	Subpopulation: students	185 freshmen physical education students	Injuries
41	Porter and Corlett (1989)	UK	Subpopulation: students	10 accident prone students and 10 non-accident prone students	No definition of accidents
42	Peters and Perry (1991)	Canada	Subpopulation: students	714 university students (traffic accidents)	Accidents
43	Hicks et al. (1993)	USA	Subpopulation: students	784 undergraduates	Injuries (medical treatment)
44	Merckelbach et al. (1994)	The Netherlands	Subpopulation: students	285 students or university employees	Injuries
45	Mandal et al. (2001)	India	Subpopulation: students	150 male students	Injuries (medical treatment)
46	Armstrong and Whitlock (1980)	Australia	Subpopulation: patients	100 psychiatric patients and 100 physically ill patients	Accidents
47	Weisbeski Sims et al. (1989)	USA	Subpopulation: patients	501 survivors of violent trauma	Injuries (hospital care)
48	Smith et al. (1992)	USA	Subpopulation: patients	10,894 trauma patients	Injuries (hospital care)
49	Poole et al. (1993)	USA	Subpopulation: patients	200 trauma, 100 emergency non-trauma, and 100 elective surgery patients	Injuries (hospital care)
50	Hedges et al. (1995)	USA	Subpopulation: patients	22,121 trauma patients	Injuries (hospital care)
51	Gubler et al. (1996)	USA	Subpopulation: patients	9424 elderly trauma patients and 37,787 uninjured elderly	Injuries (hospital care)
52	Madden et al. (1997)	USA	Subpopulation: patients	34,378 trauma patients	Injuries (hospital care)
53	Poole et al. (1997)	USA	Subpopulation: patients	46 intentional trauma, 74 non-intentional trauma, and 63 elective surgery patients	Injuries (hospital care)
54	Lowenstein et al. (1998)	USA	Subpopulation: patients	923 trauma patients	Injuries (hospital care)
55	Ponzer et al. (1999)	Sweden	Subpopulation: patients	120 recurrent trauma and 225 single trauma patients	Injuries (hospital care)
56	Kirschenbaum et al. (2000)	Israel	Subpopulation: patients	123 patients with repetitive work injuries and 77 first-injured workers	Injuries (hospital care)
57	Marusic et al. (2001)	Slovenia	Subpopulation: patients	43 injured patients and 43 non-injured hospital based controls	Injuries (hospital care)
58	Harano et al. (1975)	USA	Subpopulation: traffic	231 car drivers without and 196 car drivers with >2 car accidents	Accidents
59	Blom et al. (1987)	The Netherlands	Subpopulation: traffic	319 bus drivers	Accidents
60	Jin et al. (1991)	China	Subpopulation: traffic	31 car drivers without and 31 car drivers with >3 accidents	Accidents
61	Cale (1992)	Israel	Subpopulation: traffic	72 car drivers with >1 accident	Accidents
62	West (1995)	UK	Subpopulation: traffic	316 novice drivers and 376 experienced drivers	Accidents
63	Maycock (1997a)	UK	Subpopulation: traffic	996 heavy good vehicle drivers	Accidents
64	Maycock (1997b)	UK	Subpopulation: traffic	4621 car drivers	Accidents
65	West and Hall (1997)	UK	Subpopulation: traffic	376 car drivers	Accidents
66	Blasco et al. (2003)	Spain	Subpopulation: traffic	71 bus drivers	Accidents
67	Pickett et al. (2003)	Canada	Subpopulation: traffic	990 children (0–1 years)	Injuries (hospital care)
68	Howard et al. (2004)	Australia	Subpopulation: traffic	2342 commercial vehicle drivers	Accidents
69	Keall and Frith (2004)	New Zealand	Subpopulation: traffic	6152 drivers with two-car crashes (at least one 65-year-old involved)	Injuries
70	Mohr and Clemmer (1988)	Mexico	Subpopulation: work	610 off-shore petroleum workers	Injuries (medical treatment)
71	Wellman et al. (1988)	USA	Subpopulation: work	144 police officers	Injuries
72	Lardent (1991)	USA	Subpopulation: work	47 crashed fighter pilots and 44 pilots without crashes	Accidents
73	Baker et al. (1995)	USA	Subpopulation: work	534 pilots with 1 crash and 20 pilots with 1 crash	Accidents
74	Wassell et al. (1999)	USA	Subpopulation: work	608 employees of an electrical utility company	Injuries (medical treatment)
75	Virtanen et al. (2003)	Finland	Subpopulation: work	69,629 farmers	Injuries
76	Garraway et al. (1995)	UK	Subpopulation: sports	1169 rugby players	Injuries
77	Hutchinson et al. (1995)	USA	Subpopulation: sports	1440 (age unknown) boys playing for tennis championship	Injuries (medical treatment)
78	Stretch (2001)	South Africa	Subpopulation: sports	88 elite cricketers	Injuries
79	Faude et al. (2005)	Germany	Subpopulation: sports	165 female soccer players	Injuries

Note: Some studies were based on the same empirical dataset.

[a] British Birth Cohort (UK).

[b] Kaiser Foundation Health Plan (USA).

[c] Louisville Twin Study (USA).

We found 16 studies that concentrated on the occurrence of accidents, regardless of whether injuries resulted. Most studies, however, focused on accidents resulting in actual physical injury (60). Eighteen of these reported on injuries whether or not medical treatment was needed. Another 19 articles reported only on injuries needing medical attention in a hospital. Other studies (23) too included subjects requiring medical attention for their injuries, but were less specific about what kind of medical care was obtained. Thus, although some studies included accidents regardless of whether they caused injuries or not, most studies focused on accidents resulting in injuries requiring medical attention.

Concerning the various operationalisations of accident proneness, it became clear that we had to make some categorisation to clarify the concept. First, the severity of a person's accident proneness is often measured by the number of accidents. Viewed from this angle, accident proneness is often called accident or injury *liability*. In general, authors have used accident rates in individuals as an outcome to find correlates and predictors of accident proneness.

Second, four studies used accident rates to categorise individuals into groups with low, normal, and high accident proneness. Blasco et al. (2003) studied accidents in bus drivers and they used the mean accident rate (six accidents per person per year) to form a "normal" accident group (accident rate around the mean), a "low" accident group (accident rate one standard deviation below the mean), and a "high" accident group (accident rate one standard deviation above the mean). Mandal et al. (2001) created three injury groups in students: three or less, three to nine, and nine or more lifetime injuries. Manheimer and Mellinger (Manheimer and Mellinger, 1967; Mellinger and Manheimer, 1967) also formed three injury groups in 15-year-old children, separately for boys and girls. The cut off points of the study of Mandal and the studies of Manheimer and Mellinger were similar, but neither explained specifically why they used these cut off points, although Manheimer and Mellinger pointed out that cut off points were determined 'relative to other children'. The cut offs of the accident groups of bus drivers were much higher, presumably due to the amount of time that bus drivers spend in traffic.

Third, a distinction in two groups was made in 14 case-control studies, namely an accident and a non-accident group. In these studies, hardly any prevalence rates of accidents were given, since the main focus was to find associations or even predictors of accident proneness. Six of these studies focused on children. Matheny (1986) compared 1–3-year-old children with two or more injuries with children without injuries. Nyman (1987) focused on 2-year-old children with an injury as compared to children with an illness. Qin (2005) aimed at 8-year-old children with and without injuries, as did Vollrath et al. (2003) with 9-year-olds and Graham et al. (1993) with 11-year-olds. All injuries discussed in these studies required medical attention. Only Swensen et al. (2004) focused on accident claims in 16-year-old adolescents with and without Attention Deficit Hyperactivity Disorder. Four studies focused on adult patients. Patients with non-intentional injuries were compared with hospital-based controls (Marusic et al., 2001), with patients with intentional trauma and with elective surgery patients (Poole et al., 1997), or with non-trauma surgery and elective surgery patients (Poole et al., 1993). The mean age of patients varied between 32 and 55 years. In elderly patients, Gubler et al. (1996) compared patients requiring medical attention for their injuries at a hospital with uninjured elderly (mean age over 66 years). Four studies focused on traffic accidents where a non-accident group was compared with an accident-group (Harano et al., 1975; Jin et al., 1991; Lardent, 1991; Plummer and Das, 1973).

Fourth, three papers compared groups of individuals with one accident to a group of individuals with repeated accidents. The latter were identified accordingly as accident prone individuals. Patients with repetitive work-related injuries were compared with patients with a first work-related injury by Kirschenbaum et al. (2000); both groups of patients needed medical attention at the hospital for their injuries. Ponzer et al. (1999) also concentrated on injuries and compared patients with recurrent injuries that needed medical attention at the hospital with patients with a single injury. Pilots with more than one crash were compared with pilots with only one crash by Baker et al. (1995).

Finally, Porter and Corlett (1989) compared an accident-prone group with a non-accident prone group by means of the outcome of the Accident Proneness Questionnaire, regardless of the number of accidents in these groups.

In summary, studies categorised individuals into groups with ascending accident rates or made non-accident, accident, and repetitive accident groups of individuals.

Studies did not only use various definitions of accidents and accident proneness, but they also used different contexts and subjects in which accidents occurred. Regarding the context and prevalence of accidents, a differentiation can be made between 15 studies that used a sample of the general population (Table 2) and 64 studies that used a sample of a specific subpopulation based on the context in which accidents occurred or based on other characteristics of the subgroup.

Three studies of the general population reported on residents of a specific geographical catchment area. The difference in injury rate between the studies of Lindqvist (1989) (0.12 injuries per person per year) and Jansson et al. (2004) (0.02 injuries per person per year), and the study by Nicholl et al. (1995) (1.23 injuries per person per year) is probably attributable to differences in how accidents and injuries were defined. Lindqvist and Jansson only included injuries requiring medical care, whereas Nicholl included sports and exercise related injuries not necessarily requiring medical attention. Therefore, it is not surprising that Lindqvist and Jansson found lower prevalence rates of injuries than Nicholl. The majority of adults in the three studies did not have any injury at all (86–92%).

Twelve studies of the general population reported injury rates in children. The highest injury rate of 1.54 injuries per child per year was found in 5–11-year-old children in a study of Bradbury et al. (1999). Injury rates ranged from 0.05 injuries, in 6–8-year-old children (Boyce and Sobolewski, 1989), to 0.55 injuries, in 0–10-year-old children (Spady et al., 2004) per child per year in the remaining studies.

General population studies distinguished accidents occurring in home, traffic, sports and work environments (Lindqvist,

Table 2
Observed and expected prevalence rates of accidents in studies that used a sample of the general population

Study	Subjects	Accidents	Period	0		1		>1		χ^2
				Obs	Exp[a]	Obs	Exp[a]	Obs	Exp[a]	
(1) Lindqvist	41,432	4,926	1.00	89.5	88.8	9.4	10.6	1.2	0.7	224.32*
(2) Nicholl[b]	17,564	1,803	0.08	91.9	90.2					
(3) Jansson	4,036	1,044	12.00	86.0	77.2	8.6	20.0	5.4	2.8	397.12*
(4) Langley	927	892	7.00	40.9	38.2	34.4	36.8	24.7	25.0	1.79
(5) Gallagher[b]	87,022	19,483	1.00	77.7	80.3					
(6) Bijur	11,966	7,270	5.00	56.1	54.5	31.6	33.1	12.2	12.4	14.13*
(7) Bijur	10,394	6,288	5.00	57.9	54.6	29.2	33.0	12.7	12.4	67.45*
(8) Boyce	54,874	8,429	3.00	86.2	85.8	12.8	13.2	1.0	1.1	7.03*
(9) Kogan	8,094	2,671	3.00	78.7	78.7	16.8	23.7	4.6	4.4	219.81*
(10) Scheidt	17,110	2,773	1.00	86.4	86.4	11.6	13.8	2.0	1.2	165.96*
(11) Bradbury[b]	295	455	1.00	36.3	36.3					
(12) Schwebel	59	70	6.00	35.6	35.6	28.8	36.2	35.6	33.3	0.61
(13) O'Connor[c]	10,238	4,197	0.75	74.0	74.0	11.0	27.2	15.0	6.4	2251.52*
(14) Bijttebier	209	343	6.00	27.8	27.8	28.7	31.8	43.5	48.8	7.58*
(15) Spady	96,359	242,456	9.00	16.0	16.0	21.0	20.3	63.0	71.6	8494.60*

[a] Expected prevalence rates were based on the Poisson distribution.
[b] Studies provided no data about prevalence rates of one or multiple accidents.
[c] Total number of accidents was calculated assuming that subjects with more than one accident had two accidents (underestimation of total and mean scores).
* $p < 0.05$.

1989). As shown in Table 1, 12 studies in specific subpopulations described traffic accidents, six studies focused on work-related accidents, and four studies described sports injuries. In sport injuries studies, recurrent or repetitive injuries are defined as injuries that are a recurrence of a previous injury, whereas in all other contexts a repetitive or a recurrent injury is defined as a new injury, not necessarily (and often not preferably) related to a previous one.

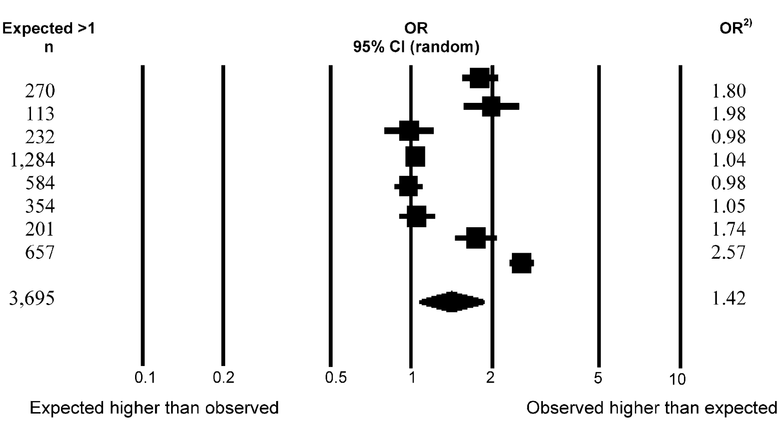
Another differentiation can be made between studies that used different groups of subjects regardless of the context of their accidents. We found 26 studies dealing with children, eight papers reporting on students and 12 studies reporting on patients.

4. Meta-analysis of accident proneness

Although a number of studies presented the proportion of accident repeaters, we concluded that no overall prevalence rate of accident proneness could be given due to different observation periods. We decided to perform a meta-analysis of the distribution of accidents in the general population, to compare the observed number of individuals with repeated accidents with the number expected by chance. Table 2 shows the proportion of individuals with no injuries, one injury and two or more injuries in a specific time period in the studies of the general population. We compared this distribution with a distribution based on chance alone (Poisson). Individuals of all studies of

Study	Subjects	Observed >1 n	Expected >1 n	OR[2)]	95% CI
Lindqvist (1)	41,432	483	270	1.80	1.55-2.09*
Jansson (3)	4,036	218	113	1.98	1.57-2.50*
Langley (4)	927	229	232	0.98	0.80-1.21
Bijur (7)	10,394	1,324	1,284	1.04	0.95-1.12
Boyce (8)	54,874	573	584	0.98	0.87-1.10
Kogan (9)	8,094	370	354	1.05	0.90-1.22
Scheidt (10)	17,110	347	201	1.74	1.46-2.08*
O'Connor (13)[1)]	10,238	1,536	657	2.57	2.34-2.83*
Total	1,47,105	5,080	3,695	1.42	1.05-1.92*

Test for heterogeneity Q-value=293.8 df=7 p<0.001
Test for overall effect z=2.27 p<0.05



(1) Total number of accidents was calculated assuming that subjects with more than one accident had two accidents (underestimation of total and mean scores)
(2) Odds ratio of the observed and expected proportion of individuals with more than one injury (random model)
* p < 0.05

Fig. 1. Meta-analysis observed and expected clustering of accidents in the general population.

the general population were significantly different distributed than the Poisson distribution, except for the study of Schwebel and Plumert (1999) (probably due to a small sample size). All observed percentages in the non-injury group were larger than expected percentages. Six studies observed higher frequencies in the one injury group than expected. Although four studies reported lower frequencies in this group than expected, two of these studies provided prevalence rates of individuals with more than two injuries as well and these rates also appeared to be higher than expected by a distribution based on chance alone. Overall, the results show that accidents were not distributed at random, but instead there is systematic variation in the distribution of accidents amongst individuals in the general population.

In order to perform a meta-analysis on the presence of accident proneness, we calculated odds ratios for the observed and expected number of repeaters in studies of the general population. Studies of the general population were included when they provided sufficient data and when mean injury rates did not exceed one injury per observation years. The results of the meta-analysis of the eight remaining studies are shown in Fig. 1. Odds ratios of the studies varied from 0.98 to 2.57. The pooled odds ratio of 5080 observed repeaters and 3695 expected repeaters was 1.40 (CI 1.34–1.46, $p < 0.001$). Because the odds ratios between these studies were heterogeneous (Q-value 293.8, $p < 0.001$), we calculated the random pooled odds ratio as well. This resulted in a similar estimate of the overall odds ratio (OR 1.42, CI 1.05–1.92, $p < 0.05$). The results indicate that accidents do cluster in the general population and that this clustering is more prevalent than expected by chance.

To test for publication bias, we examined the symmetry of a funnel plot. No asymmetry was detected and Egger's regression test showed no significant p-value of the intercept ($p = 0.87$).

5. Discussion and conclusion

Meta-analysis of studies that used a sample of the general population revealed that accidents cluster in individuals, and that this clustering is higher than the clustering one would expect by chance alone. Thus, there are more individuals with repetitive injuries than would be expected by chance alone. Observations in subsamples of Boyce and Sobolewski (1989) and Greenwood and Yule (1920), also revealed this clustering of accidents. This study adds considerably to this knowledge since we provided an overall estimate of this clustering in the general population using a formal meta-analysis.

The results should be considered in relation to the study limitations. It should be noted that the heterogeneity between the studies included in the meta-analysis was large. The overview of operationalisations of accident proneness provides some clues for this heterogeneity. First, studies used different definitions of accidents: studies observing injury rates have higher prevalence rates than studies focusing on injuries requiring medical attention. Second, studies focused on different age groups, e.g., children or adults. And finally, observation periods varied considerably among studies. We tried to extend the meta-analysis with the analyses of subgroups of studies, e.g., short versus long follow-up, adults versus children. However, despite significant variation between groups, heterogeneity within these subgroups was still very large.

One can thus calculate that an accident prone group exists; however, it is still difficult to identify the accident prone individuals that compose this group, because individuals can experience multiple accidents because of chance alone and also because of a higher exposure to risk independent of personal factors. Based on this overview, we have the following recommendation for future studies. First, it is important that future studies use comparable definitions of accident proneness. In our opinion, studies should be restricted to accidents leading to injuries requiring medical care. In this way, the group of accidents is less heterogeneous than when all accidents are included. Moreover, the primary objective of medical research is to study health problems. Second, this study shows that accidents cluster in individuals. Thus, case-control studies appear more suitable than studies using continuous outcome measures (e.g., studying accident liability). However, we were unable to give a threshold for caseness. Third, circumstances of accidents should be taken into account when studying accident proneness. Individuals may be more or less exposed to risk which results in different accident rates and future studies should try to determine the amount of risk exposure. Also, accidents occur in different contexts and studies could be categorized in studies concerning traffic, work, sports and home accidents. These contexts may also provide some clues about causes of accidents, which may directly be related to personality characteristics that form the core of accident proneness. For example, the more 'self-inflicted' injuries are, i.e., due to an individual's own characteristics (e.g., clumsiness) or actions (e.g., risky behaviour), the higher the chance that the victims of these accidents can be marked as accident-prone individuals.

Accidental injuries are and will be an important cause of disability and death especially in younger age groups (Murray and Lopez, 1996; Ruwaard and Kramers, 1993). Although the concept of accident proneness remains at dispute, review and meta-analysis of the literature clearly shows that the distribution of accidents among individuals is not based on a chance distribution (i.e., the Poisson distribution); there are more individuals with repetitive injuries than would be expected by chance alone. And these repetitive injury patients often use a disproportionate part of medical services as well (Jansson et al., 2004). Once accident-prone individuals can be identified, it becomes possible to disclose possible predictive and protective factors of accident proneness and this will make the development of preventive strategies possible in time.

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